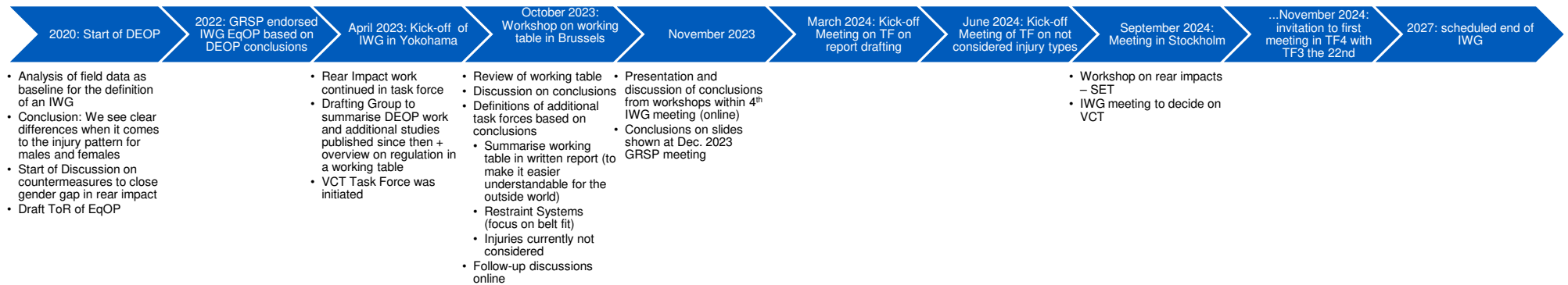


# IWG EqOP – 8th meeting

November 7, 2024

# EqOP Timeline



# Strategic goals

- Equitable and enhanced protection of a diverse population
  - Passenger car occupants given priority
- Robust, inclusive and effective regulatory solutions
  - For protecting a diverse population in an equitable way

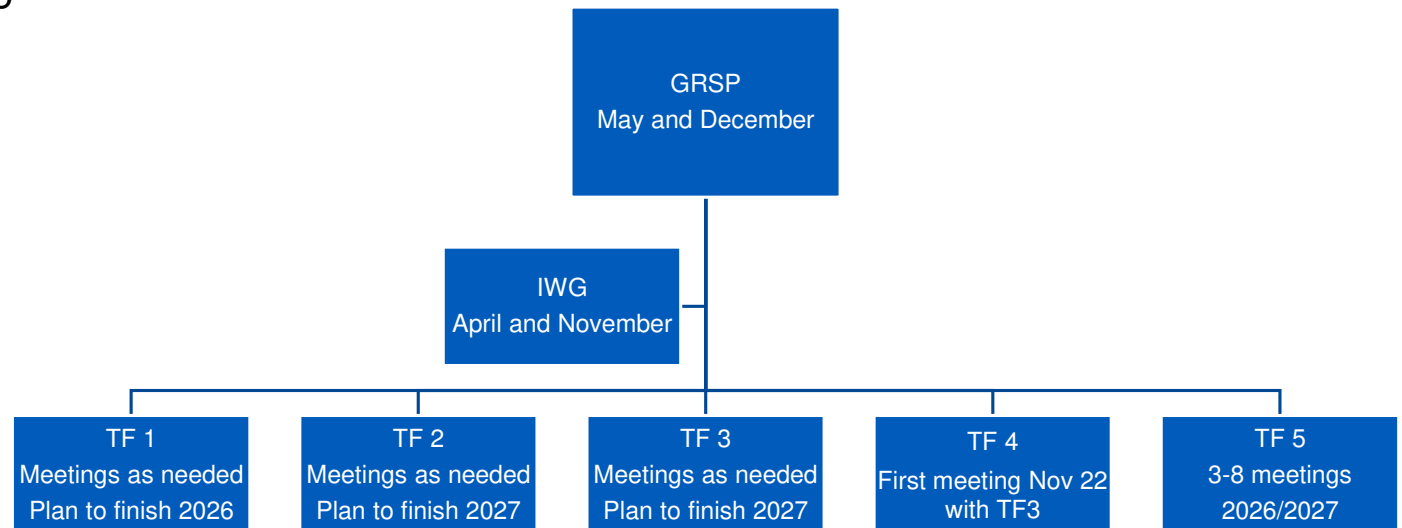
# Operational goals

1. Diversity Issues:  
Present a map of diversity issues which should be addressed by regulatory upgrades directly vs gaps where more research is needed – Dec 2023 (TF1 putting this into a written format – 2026)
2. Regulatory Changes:  
Determine how greater diversity should be implemented in the UN crash safety regulations
  1. In order to benefit the female population as soon as possible with available tools, the IWG should first provide a recommendation on the usage of existing ATDs.
  2. Full report on attaining equity in crash safety regulations to GRSP in May 2025
3. Virtual Crash Testing:  
Assess VCT as a method in concerned regulations to improve equity in occupant protection further – Dec 2027
4. Regulatory Shortcomings:  
Identify shortcomings of existing regulations that hinders the protection of a diverse population – Dec 2027

# Upcoming meetings 2025

Estimated number of meetings 2025

- GRSP
  - 2 per year
  - May and December
  - In-person meetings
- IWG digital meetings
  - 2 per year
  - April and November
- Task related meetings
  - 8-12 meetings (or as needed)
  - Digital



# Concluding discussion on UNECE Gender-responsive guidelines, workshop in Stockholm

- We discussed whether adult men and women are a too narrow scope.
- As we know that several distributions describing the body shape significantly differ between females and males, it makes sense to start with the discrete distinction of sex (female/male/non-binary) and then go into detailed distribution of each group.
- In cases where we know that the sex and body shape does not affect the response, such distinction is not meaningful.
  - For the regulations where it is meaningful, the chairs will prepare a first list where the gender-responsive guidelines should be applied for the May session of GRSP.
- The questions from the UNECE guidelines can help clarify the knowledge which is needed and ensure that the regulatory framework is inclusive. These guidelines can be useful when drafting new vehicle regulations.
  - Will men and women be impacted by the regulation?
  - Is it possible that there may be different impacts for men and women?
  - Is there sufficient data to assess potential gender impacts of the regulations?
  - What assumptions are being made? What are the limitations of those assumptions?
  - Men and women are not homogenous groups, are further modifications needed to make the regulation suitable for men and women?

# Conclusions of Workshop 2 (Equity issues)

1/2

- Field studies show that injury risk depends on
  - crash severity
  - vehicle crashworthiness (e.g., rating result, vehicle size, mass, age of the vehicle (market introduction))
    - Occupant protection of passenger vehicles has improved over the years.
  - seat position (driver vs. passenger / front vs. rear)
  - age of occupant
  - BMI / body weight of occupant
  - gender of occupant
  - stature of occupant
- Interaction of parameters often different for females and males
  - Difference between males and females more often reported for younger groups, age distribution for fatally injured occupants
  - Interaction of BMI and gender (different body shapes, fat distributions, belt fits)
  - Crash severity (females more likely to be in smaller and struck car)
  - Females more likely to be passenger (front and rear)
- Relevance is different for different injury and crash types (not one group at highest risk in general) and statistical models applied

## Conclusions of Workshop 2 (Equity issues) 2/2

Identified equity issues based on review of field data:

- Head injuries – different conclusions in different studies; further review also with simulation studies will be required (many interacting factors).
- Soft tissue neck injuries in rear-end impact.
- Extremity injuries in frontal crashes.
- Thoracic injuries in frontal and side crashes.
- Abdominal injuries in frontal crashes - different conclusions in different studies; further review also with simulation studies required.



## Conclusions of Workshop 2 (Research gaps) 1/2

- Understanding of the interaction of gender with other parameters:
  - Age
  - Anthropometry
    - Height
    - Weight
    - BMI
    - The Waist-to-Hip Ratio (WHR)
    - Shoulder Height Sitting (SHS)

## Conclusions of Workshop 2 (Research gaps) 2/2

- Pregnant females.
- Understand the injury mechanisms causing equity issues for leg injuries, in particular lower leg & ankle.
- Missing tools for injuries and sizes which have not been in focus before (e.g., not clear if ankle injury can be assessed with THOR, no criterion now).
- Missing injury criteria for ankle.

# Key take away messages from field data studies

- Injury risk depends on
  - crash severity
  - vehicle crashworthiness (e.g., rating result, vehicle size, age of the vehicle (market introduction))
  - seat position (driver vs. passenger / front vs. rear)
  - age of occupant
  - BMI of occupant
  - gender / sex
  - stature of occupant? (Only available in a few studies)
- Relevance different for different injury and crash types (not one group at highest risk in general) and statistical models applied
- Interaction of parameters often different for females and males
  - Difference between males and females more often reported for younger groups, age distribution for fatality injured occupants
  - Interaction of BMI and gender (different body shapes, fat distributions, belt fits)
  - Crash severity (females more likely to be in smaller and struck car)
  - Females more likely to be passenger (front and rear)

→ **Compatibility not part of the IWG work**

(November 2023)

# Summary of Equity Issues (1/2)

- Head injuries – different conclusions in different studies; further review also with simulation studies required (many interacting factors and different injury types)
  - Significant higher head injury risk for females (Abrams and Bass, 2022 for AIS2+, 3+ and fatalities; Craig et al., 2023 for AIS2+)
  - Significant higher risk for brain injuries for females (Antona-Makoshi et al., 2018; Forman et al., 2019)
  - Significant higher risk for males (Craig et al., 2023 for AIS3+; Nutbeam et al., 2022 for trapped; Wallbank et al., 2023 for AIS2+ in frontal; Forman et al., 2019 for skull fractures); Higher risk for males (Ostermaier, 2021)
  - No significant differences between females and males (Kullgren et al, 2020; Forman et al., 2019 for AIS 4+ brain injuries – BMI and age significant)
  - The probability of head injuries decreases for male drivers versus car model year (Ryan and Knodler, 2022)
- Neck injuries: several studies agree on higher risk for females
  - several studies agree on higher risk for females for (soft tissue) neck injuries; it seems that females have not benefitted as much from protective systems as males with higher risks for younger group (Kullgren et al., 2020 Kullgren et al., 2023, Linder et al, 2032, Kullgren et al., 2010)
  - For AIS2+ and AIS3+ significant higher risks for males + significant effect of age shown in the recent NHTSA study (Craig et al., 2023); Extremity injuries (frontal crashes)
  - For trapped occupants, significant higher odds of dens fractures (C2) for females (Nutbeam et al., 2022)
- Spine: different conclusions in different studies; further review also with simulation studies required (different injury types)
  - Higher risk for older occupants (Kullgren et al., 2020; Craig et al., 2023)
  - Significant higher risk for females
    - for the spine in general and specifically spinal cord injuries and compression fractures in trapped incidents (Nutbeam et al., 2022);
    - For AIS2+ and AIS3+ thoracolumbar injuries (Craig et al., 2023)
  - No significant difference for females compared to males (Kullgren et al., 2020)

(November 2023)

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# Summary of Equity Issues (2/2)

- Thoracic injuries: several studies agree on higher risk for older occupants
  - Significant higher risk for older occupants (Kullgren et al., 2020, Craig et al., 2023, Wallbank et al, 2023)
  - Smaller odd for high BMI (<30) group – significance not evaluated (Craig et al., 2023)
  - Significant higher risk for males (Craig et al., 2023, Nutbeam et al., 2023 for trapped)
- Abdominal injuries in frontal crashes - different conclusions in different studies; further review also with simulation studies required:
  - Higher risk/odds for females (Abrams and Bass, 2022: for young females, Ryan and Knodler, 2022: for rear-end crashes)
  - No difference in risk/odds between females and males (Kullgren et al., 2020; Nutbeam et al., 2022, Wallbank et al., 2023)
  - Higher risk/odds for males (Craig et al., 2023)
  - Age dependent risk/odds (Craig et al., 2023; Wallbank et al., 2023: in frontal crashes; Abrams and Bass, 2022: interaction with gender)
  - BMI dependent risk/odds (Craig et al., 2023: lower odds for BMI 30+, significance not evaluated)
- Lower extremities – several studies agree on higher injury risk for females; interaction with BMI reported in recent study by IIHS:
  - Higher risk for females (Craig et al., 2023: overall, for foot & ankle, leg (only AIS3+); Kullgren et al., 2020; Ryan and Knodler, 2022; Nutbeam et al., 2022: for pelvis; Ostermaier et al., 2021: overall, pelvis; Brumbelow, 2023: interaction with BMI, Wallbank et al, 2023)
  - Higher risk for higher age (Wallbank et al, 2023: only for frontal crashes, Craig et al, 2023)
- Upper extremities- studies agree on higher injury risk for females:
  - Higher risk for females (Kullgren et al., 2020; Craig et al., 2023)
  - Higher risk for older occupants (Craig et al., 2023)
  - Higher risk for BMI 30+ occupants (Craig et al., 2023: significance not evaluated)

(November 2023)

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# Conclusions of Workshop 2 (Agreed task forces)

1. TF Drafting Team for the Report on equity issues: continue to work on the worktable and draft written report.
2. TF on rear impact seat assessment with focus on soft tissue neck injuries (whiplash associated disorders)
3. TF on Virtual Crash Testing
4. TF on restraint system requirements
  - a. Geometric requirements for seatbelt
  - b. Dynamic requirements / system performance
5. TF on extension of assessments towards currently not considered injury types with high frequency and risk of PMI
  - a. Lower extremity injuries in frontal and side impacts
  - b. Upper extremity injuries in frontal and side impacts
  - c. Brain injuries in frontal and side impacts
  - d. Soft tissue neck injuries in frontal and side impacts

# Task forces

reports

## Following tasks important in most task forces

- Reviewing research
- Close collaboration with industry, other working parties, and research for filling knowledge gaps
- Review of concerned regulatory requirements
- Explore opportunities to improve robustness of concerned regulations
- Prioritization based on relevance of the injury



# Task Force 1 – Drafting team

- **Meetings:** two to date (March and April, 2024)
- **Outputs**
  - Established purpose/scope/member roles
  - Created draft outline and website for co-editing report
  - Established timeline/milestones (18 months; target publication at 2026 ESV)
- **Status / Current Actions**
  - TF1 members have volunteered to draft certain report chapters
  - Updating data table with new publications/expanded data elements for use in report
- **Next steps**
  - Finish revised publication data table
  - Complete drafts of selected chapters
  - Schedule TF1 meeting #3 after sufficient progress on revised data table and exemplar chapters (November 2024)

## Task Force 2 – Rear impact assessment

- 4 on-line meetings
- 1 in-person workshop
- 4 ad hoc on-line meetings to discuss proposals

# TF2

- Explore and discuss how to address the need for a forgiving seat – focus on head restraints and seatback.
  - Eliminate poor design of seatback and head restraints.
- Explore the SETs – Seat Evaluation Tools that has been developed in EU project VIRTUAL.
- Identify any shortcomings of existing regulations and related standards.
  - Can current test protocols be misapplied to optimize crash performance for the specific test conditions and test dummies in a narrow way that is detrimental to the protection of a diverse population?
- Discuss and understand the possibilities and challenges with virtual crash testing.
  - Knowledge gaps
  - How can we develop a robust regulation?

## TF2 Next steps

- Next meeting January 23, 2025
  - Agenda
    - Robustness is key to improvement,
      - Continue discussion on how to proceed on what we know will improve safety performance.
      - Discussion about optional dynamic test with BioRid with long term plan for including one more size in the test.
    - IIHS presenting: on-going rear impact parametric study
    - Humanetics presenting: roadmap to EvaRID

## Task Force 3 – Virtual Crash Testing, VCT

- ToR: ” Explore and advance the current state-of-the-art of virtual crash testing to determine and increase its capability as a tool and process to evaluate equitability, including a specific assessment of the state-of-the art virtual human body models, i.e., virtual models of humans, particularly the possibilities for a safety performance evaluation at a higher level of detail considering diversity.”

# TF3 Proof of concept

- Virtual testing to improve equitable occupant protection
- Frontal loading conditions on frontal row
- Loadcase based on UN R137 (injury assessment) and/or UN R21 (kinematics; as fallback)  
→ to be discussed in the next TF3 meetings
- Investigation of interaction with vehicle environment for different body shapes
- Define load-case dependent requirements for Human Models (Injuries vs. Kinematics)
- Define also testable conditions for validation
- Proof of concept as basis for decision making for GRSP/WP29 on how to proceed with virtual crash testing and on which level
- Discussion in next coming GRSP meeting(s) how to deal with low volume CMs

## Task Force 4 – Restraint system requirements

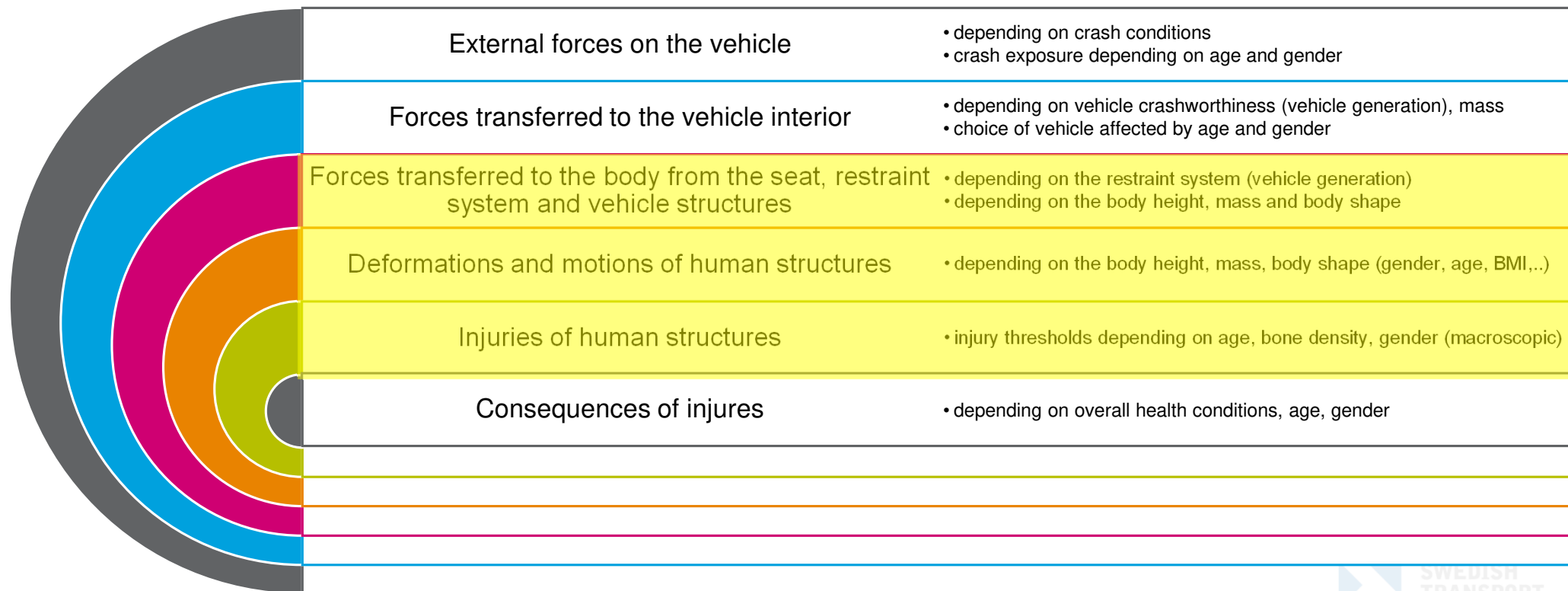
- First meeting on November 22 in collaboration with TF3
- Separate TF4 meeting in Jan/Feb 2025 to discuss and create workplan for TF4.
  - Draft plan on how to continue in TF4 and with future collaboration with TF3.

## Task Force 5 – Extensions to new injury types

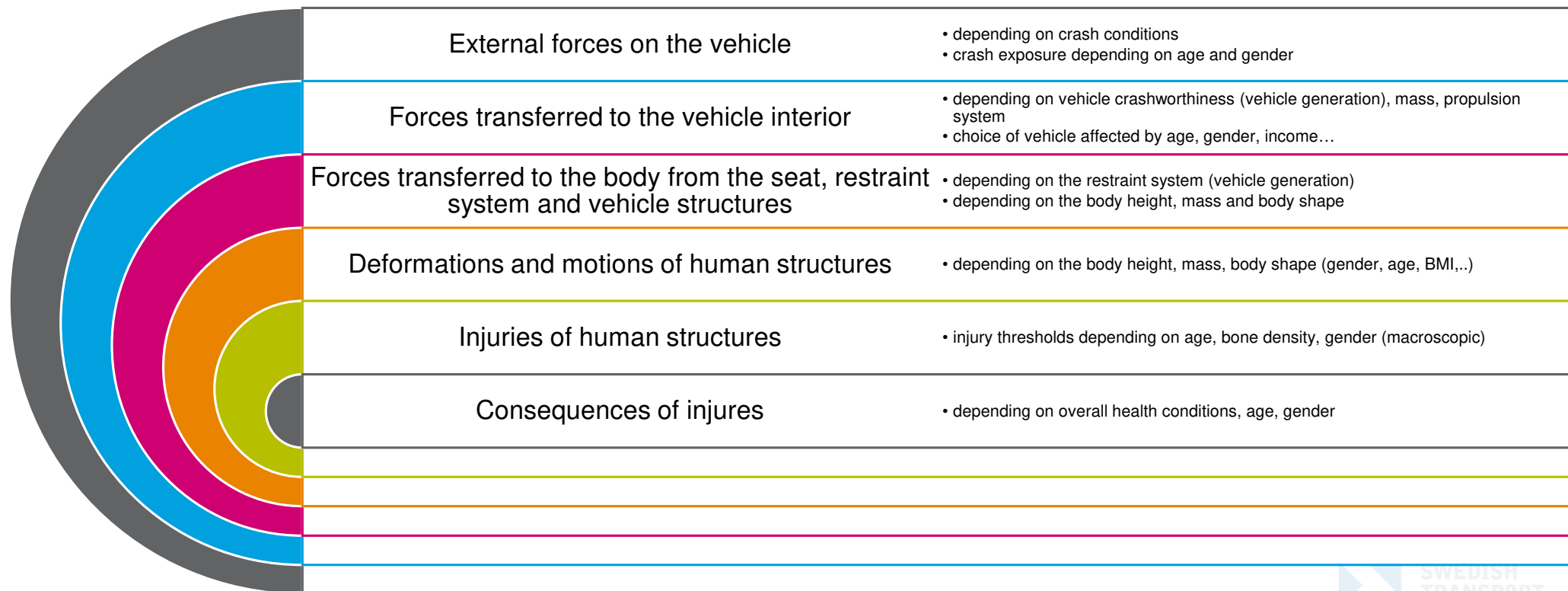
- 3 on-line workshops to date.
- Next meeting planned for November 20
  - Presentations about brain and cervical spine injury
  - Discussion about quick take aways for regulation.
- Explore how these injuries could assessed
  - review ideas on injury criteria & tools to assess them (physical tools and or virtual tools)
  - Discuss and explore how identified knowledge gaps can be closed
- Collect inputs for CBA to evaluate benefit for assessing the respective injury types.



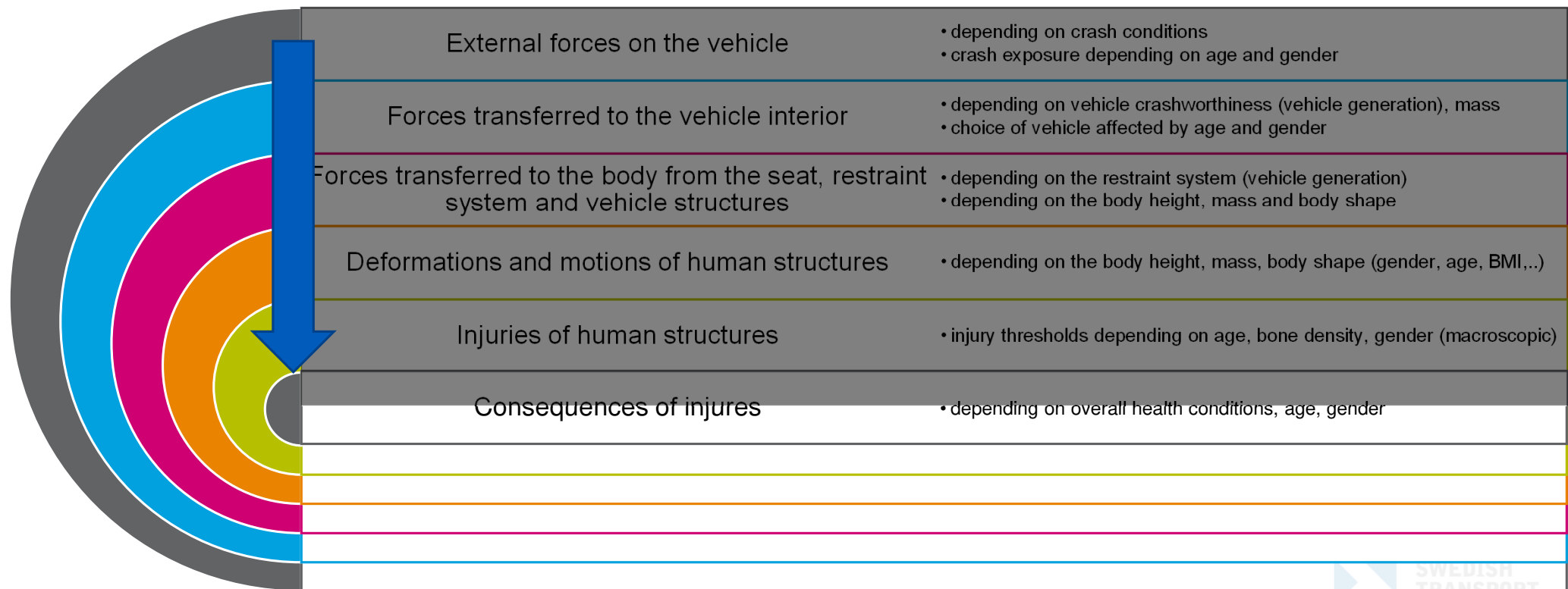
# Overview on causation chain for differences in injuries and outcomes – Focus of VCT



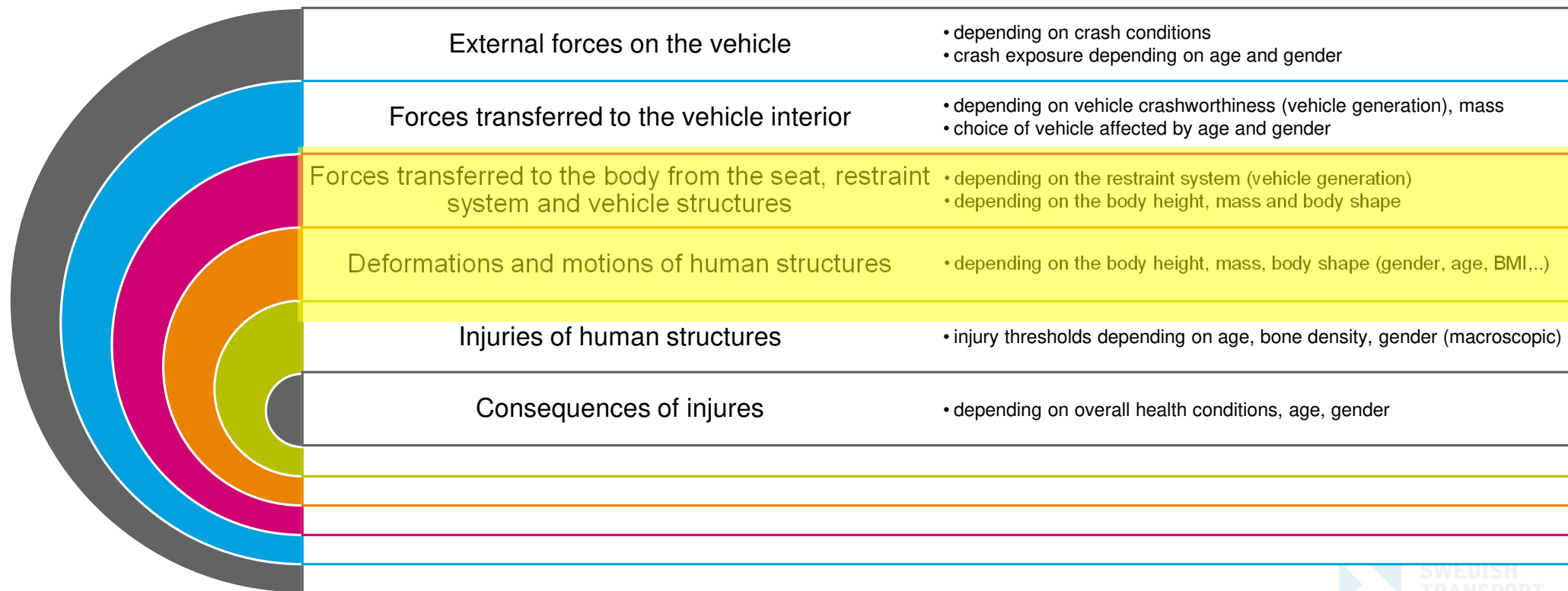
# Overview on causation-chain for differences in injuries and outcomes



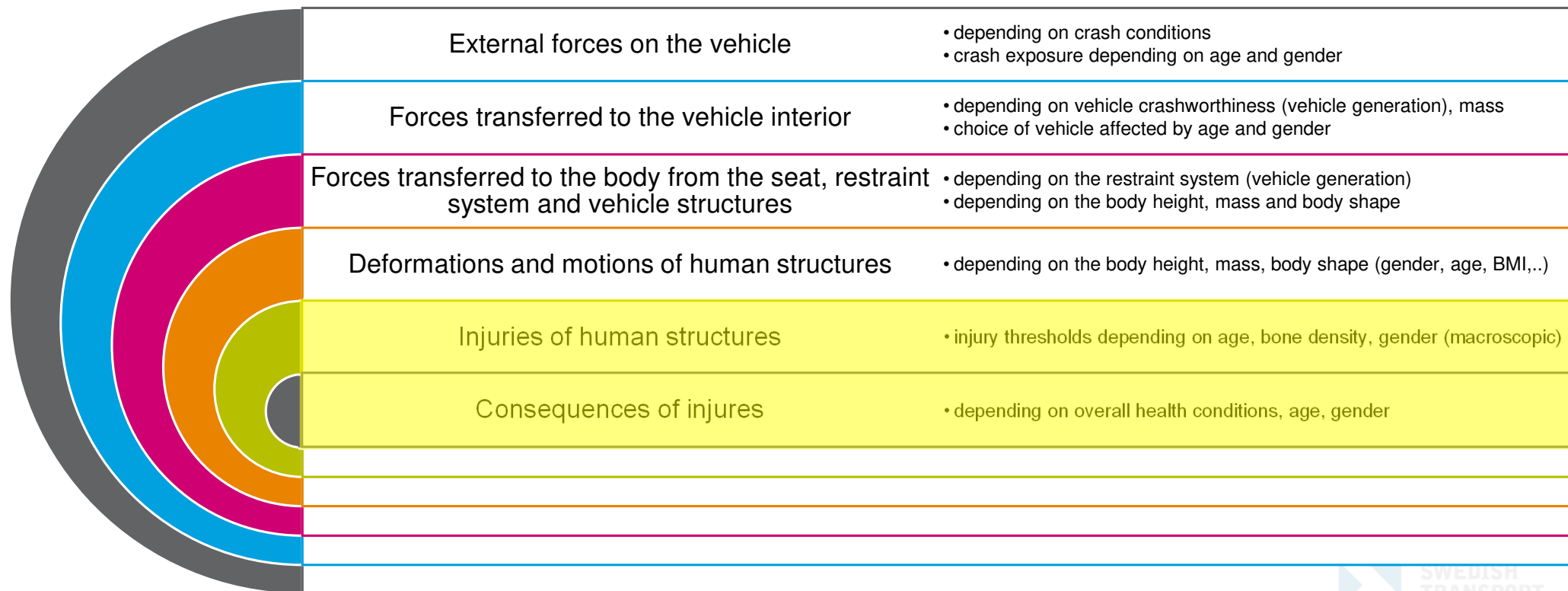
# Overview on causation chain for differences in injuries and outcomes – Field data



# Overview on causation chain for differences in injuries and outcomes – TF2



# Overview on causation chain for differences in injuries and outcomes – TF5



# Overview of related UN Regulations

Regulation	Load case and general requirements	Speed	Barrier	ATD	Limitations
UN R12	Full frontal, flat barrier	48,3-53,1 kph	N/A	N/A	-
UN R14	Safety-belt anchorages Strength test Geometry related requirements		N/A	N/A	loads are based upon occupant mass of 75 kg
UN R16	Safety-belts Frontal dynamic belt load	50 kph	Sled test ~30g	R16 Manikin 75 kg	loads are based upon occupant mass of 75 kg
UN R17 GTR 7	Seats and seat anchorages	50 kph	N/A	static based on 50M stature or dynamic test with Bio RID	Only 50M
UN R21	Interior head impact		N/A	N/A	No
UN R25	Head restraints. Geometry related requirements and strength test	N/A	N/A	N/A	head restraints optimised for test protocol conditions.
UN R32	Full perpendicular rear-end impact.	38 kph	MB 1100 kg	N/A	-
UN R34	Fuel system integrity				-
UN R94	40% Frontal offset; perpendicular Deformable barrier	56 kph		Belted Driver HIII 50M Belted Front Pass HIII 50M	only 50M tested only front occupants
UN R95	Side; Mobile Deformable Barrier; Perpendicular No door shall open during test. After impact it shall be possible to open doors, release and remove the dummy.	50 kph	MDB 950 kg	ES2 male 50th%; Front seat on the struck side	- only mid position of travel - no interaction between front row occupants - no rear occupants
UN R135 GTR 14	Pole side impact; angled	32 kph	Pole	WSID 50M Front seat on the struck side	- only mid position of travel
UN R137	Full frontal; perpendicular	50 kph		Belted Driver HIII 50M, Belted Front Pass HIII 05F	only front seat occupants covered
UN R153	Fuel system integrity				N/A

# Overview of used ATDs in related UN Regulations

ATDs	Driver				Front Passenger				Rear Passenger			
	05F	50F	50M	95M	05F	50F	50M	95M	05F	50F	50M	95M
UN R12	-	-	-	-	-	-	-	-	-	-	-	-
UN R14	-	-	-	-	-	-	-	-	-	-	-	-
UN R16	-	-	R16 Manikin 75 kg* static based on 50M stature or dynamic test with Bio RID	-	-	-	R16 Manikin 75 kg*	-	-	-	R16 Manikin 75 kg*	-
UN R17	-	-	-	-	-	-	-	-	-	-	-	-
UN R21	optional simulations	-	optional simulations	optional simulations	optional simulations	-	optional simulations	optional simulations	-	-	-	-
UN R25	-	-	-	-	-	-	-	-	-	-	-	-
UN R32	-	-	-	-	-	-	-	-	-	-	-	-
UN R94	-	-	HIII	-	-	-	HIII	-	-	-	-	-
UN R95	-	-	ES2	-	-	-	-	-	-	-	-	-
UN R135	-	-	WSID	-	-	-	-	-	-	-	-	-
UN R137	-	-	HIII	-	HIII	-	-	-	-	-	-	-
GTR 14	-	-	WSID	-	-	-	-	-	-	-	-	-
GTR 7	-	-	static based on 50M stature or dynamic test with Bio RID	-	-	-	-	-	-	-	-	-